Ph.D. Title Proposal

on

A Multi-Layer Framework for Business Intelligence Maturity and Governance for Contemporary Data Visualization Tools

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PROPOSAL FOR TOPIC APPROVAL TO BE SUBMITTED TO THE UNIVERSITY OF MUMBAI FOR THE DEGREE OF **Ph.D. (SCIENCE AND TECHNOLOGY)** IN THE SUBJECT OF **COMPUTER ENGINEERING**

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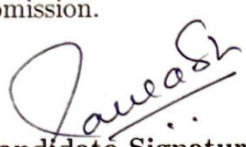
Statement by the Candidate

I wish to state that the work embodied in this synopsis titled "A Multi-Layer Framework for Business Intelligence Maturity and Governance for Contemporary Data Visualization Tools" forms my own contribution to the work carried out under the guidance of Dr. Savita Sangam at the Shah and Anchor Kutchhi Engineering College. I declare that this written submission represents my ideas in my own words and where others ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission.



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Introduction

Business Intelligence (BI) and modern Data Visualization (DV) tools like Power BI, Tableau, Qlik, and Looker—have become essential in the analytical frameworks of today's data-driven companies. These platforms allow users at every level to pull, transform, visualize, and make sense of data, which helps with both strategic and operational decisions. Still, even with their popularity, many organizations tend to use these tools in a haphazard or piecemeal way. This often results in inconsistent practices, underused features, and lost chances for creating value. A big issue is that many companies don't have a clear way to evaluate how mature these platforms are, meaning how well they are being used, how engaged users are, and what kind of impact they have on the business—or to manage them effectively with proper policies and controls.

Good governance in modern BI is crucial for keeping self-service analytics both accessible and well-managed. The trick is to find the right balance between giving users flexibility and keeping a handle on things. While self-service BI lets people investigate and act on data on their own, it comes with governance challenges like inconsistent data definitions, duplicate reports, unregulated access, rising costs, and security risks. If there's no solid governance model in place, the benefits of modern BI might get lost in disarray and inefficiency. To tackle these issues, this study suggests creating a multi-dimensional governance framework specifically designed for contemporary BI and DV settings. This framework aims to be thorough, addressing key areas of governance and will be backed by a relevant set of tools, techniques, and metrics to help implement and monitor governance effectively.

To ensure the framework is based on solid research, the literature review looks closely at academic studies, whitepapers, and industry reports from the last ten years. It examines how different areas of governance are understood and dealt with in existing research, what models or metrics have been suggested for their use, and how these align with or differ from the proposed framework. This analysis not only supports the framework's importance but also helps spot gaps in research and opportunities for innovation in BI governance.

Literature Review

Designing Maturity Assessment Framework

Early work focused on tool-selection criteria. Gina and Budree reviewed 32 studies and surfaced "tool, vendor and opinion" factors that drive adoption, arguing that selection itself is a multi-criteria decision-making (MCDM) problem [1]. Once deployed, several authors proposed quantitative evaluation models that combine expert judgement with fuzzy logic or AHP: Ghazanfari et al. built an expert system to rate the "intelligence level" of enterprise systems [2], while Rezaie et al. showed that a three-level fuzzy AHP hierarchy (fitness - flexibility - functionality) captures the performance of BI platforms and that fitness dominates the weight vector [3].

To avoid AHP's pair-wise burden, Rouhani et al. applied Fuzzy TOPSIS to rank enterprise BI alternatives, effectively handling both benefit and cost attributes [4]. Pandipati introduced VIKOR to balance conflicting criteria (accuracy vs. effort) in manufacturing-report redesign, illustrating how the method yields a compromise solution and a simple "S-R-Q" dashboard for managers [5]. Neural methods have also been explored; Yan et al. trained a backpropagation network on questionnaire data to predict an overall BI score, thereby eliminating the need for explicit weight elicitation [6].

On the maturity side, Tan et al.'s EBIM framework and Lahrmann et al.'s sociotechnical model both define staged progressions from initial to optimized/innovative states, validated through Delphi rounds and large-sample surveys, respectively [7]. However, these models predate the cloud-native DV stack and devote little attention to governance capabilities, such as cost control, access management, or CI/CD pipelines for analytics code. Brichni et al. filled part of that gap with BI4BI, a continuous-evaluation engine that mines usage logs and user feedback, but their indicators remain largely operational rather than strategic [8]. These models leverage multi-criteria assessments—often via fuzzy-AHP or expert-driven weightings—to score organisations across dimensions such as data quality, process automation, BI culture and value realisation [9].

In the evolving BI landscape, newer studies emphasize hybrid frameworks that combine organizational, technical, and analytical capabilities. For instance, Alkhaldi and AlShihi examined public sector BI maturity in the Gulf region, revealing that cultural readiness and cross-functional governance are as critical as tool adoption [11]. These findings stress the need for maturity models that go beyond technical proficiency to include leadership, adoption culture, and performance feedback loops.

Further advancements came from Razi and Alishahi, who extended maturity modeling by introducing KPIs mapped to BI capabilities for continuous tracking, and Singh and Kaur, who evaluated BI readiness in SMEs with a flexible maturity model tailored for limited-resource environments [12, 13]. Jamil and Faisal proposed a unified maturity and governance framework tailored for cloud-native BI stacks, integrating the perspectives of DevOps, data lineage, and organizational policies into maturity assessments [14]. Similarly, Hassan and Khan outlined a layered BI maturity approach that explicitly connects organizational alignment with measurable technical performance benchmarks [15]. These later studies advocate for integrated models that evolve with the BI ecosystem—accommodating rapid changes in cloud-native tools, AI integration, and real-time collaboration workflows. This reinforces the need for a comprehensive yet adaptable framework that captures both the maturity level and the governance posture of BI systems in modern enterprises. .

Designing Governance Framework

Security related governance practices involve controlling who can retrieve or publish data and insights, and under what conditions. Ensuring proper data access controls and security policies is widely viewed as critical for self-service analytics success [16,17]. The literature identifies "deciding who can use and add data" as a primary challenge when implementing self-service BI, along with defining data retention and minimum quality requirements.

Governance should ensure the BI infrastructure can handle usage growth, performance demands, and content proliferation. Surging adoption strains servers and licenses, yet empirical guidance is thin. Lennerholt's review notes that query spikes overwhelm legacy BI, and Baijens et al. call for procedural 'usage monitoring' mechanisms, but do not define KPIs such as Monthly Active Users (MAU) or render time targets [18].

Governance should ensure maintaining standards for the queries, calculations, data models, and visualizations created by end-users. Lennerholt et al. warn that if users create their own calculations without guidance, "they may use different approaches that produce different results," making metric governance essential. Case studies like Dell's indicate IT will "harden" sandboxed analytics before scaling [19], and the 2025 DataOps review highlights automated testing and linting as best practices [20].

Monitoring and optimizing the financial aspect of analytics programs – licensing, cloud resource usage, developer productivity, etc should be part of governance. Despite being critical in practice, this domain lacks concrete metrics in research. Watson and Wixom argue that governed programs outperform on ROI, but do not specify how to measure licence waste [21]. Goul et al. mention "project prioritization" but omit cost tracking. Meanwhile, Katal et al. propose real-time dashboards for budget governance in analytics-as-a-service environments [22].

Governance encompasses the practices for documenting data definitions, report usage, calculation logic, and other metadata so that users understand and trust the analytics. This domain corresponds closely with what many researchers call metadata management and lineage management in BI. Combita et al. mandate "living data dictionaries", while Baijens highlights data catalogues as procedural necessities. Oliveira et al. further stress the need for collaborative governance policies that document not just data, but context and change history [23].

BI governance is needed for the detection, handling, and prevention of failures ranging from stale dashboards to broken Extract-Transform-Load(ETL) pipelines. Academic research on BI largely subsumes these concerns under data quality management and system reliability. That is, rather than talking about 'error management' as a standalone category, researchers discuss ensuring data accuracy, consistency of reports, and robust BI systems – all of which are related to managing errors and exceptions. Clarke et al.'s matrix emphasizes Service Level Agreements(SLAs) [24], while Goul's Dell case notes support tiers but lacks recurrence KPIs. A recent study by Sharma et al. suggests embedding machine learning in governance tools to prevent refresh failures and outlier metrics [25].

Source Control refers to the versioning, change management, and backup of BI assets (such as dashboards, reports, data models, and analytical code). Historically underdeveloped, this domain has gained prominence through DataOps and MLOps adoption. Fannouch et al. and the 2025 DataOps review cite Git-based versioning as a maturity indicator, and Rashed et al. suggest bringing soft-

ware engineering-style governance to BI, including GitOps and rollback protocols for report development [26].

Recent governance models call for federated frameworks that balance local autonomy with centralized oversight. Janssen et al. propose a tiered structure where business units maintain flexibility while IT enforces shared policy baselines [27]. Furthermore, Schlegel and Castellina describe BI governance maturity curves that transition from fragmented tooling to orchestrated platform control [28]. These works support a holistic view, where governance is both organizational and technological, which requires frameworks that evolve alongside analytics practice.

Research Gap

- **Tool-centric scope:** Many models pre-date the current era of cloud-native architectures, modern semantic engines and automated data-ops pipelines, resulting in legacy-focused constructs that overlook streaming ingestion, metadata-driven governance and self-service tooling divergence. Thus, the criterion of evaluation needs to be relooked [1].
- **Subjective weight bias:** Pairwise comparisons and expert scoring introduce inconsistency and cognitive load, undermining repeatability. New-age algorithms can be utilized to enable better weights and scores [2, 3, 6].
- **Lack of metric formalisation:** The majority of the surveyed works do not define these KPIs despite acknowledging the underlying issues [16, 19, 21].
- **Operational tooling detail:** Methods mentioned only at concept level; no tool or technique clearly specified for how to track or accomplish the governance area [18, 24].
- **Integrated, end-to-end framework:** All frameworks in the literature survey focus on data governance or analytic capability, not the full life cycle [17, 18].

Aim and Objectives

Aim

The primary aim of this research is to design a comprehensive, multi-layered framework that captures the full spectrum of maturity and governance requirements for contemporary Data Visualization ecosystems. Furthermore, the framework will prescribe governance policies and evaluation mechanisms tailored to each area, ensuring consistent implementation of best practices. Ultimately, this work seeks to provide a robust, actionable framework that supports both strategic decision-making and operational oversight in modern BI and visualization environments.

Objectives

1. Design a Maturity Framework for modern Data Visualization Tools.
2. Develop evaluation metrics and apply weighted scoring methods to assess the effectiveness of the proposed Maturity Framework.
3. Design a Governance Framework for modern Data Visualization Tools.
4. Test the framework to evaluate metrics and methods outlined in the proposed Governance Framework.

Materials and Methods

The proposed research will adopt a comprehensive mixed-methods approach, leveraging qualitative analysis, quantitative modelling, and expert validation to ensure rigour, depth, and practical relevance. Initially, a systematic and extensive literature review will be conducted to thoroughly investigate existing maturity assessment models, governance frameworks, and methodologies for evaluating BI platforms. The goal of this phase is to synthesize current understanding, identify significant gaps in existing approaches, and establish a robust theoretical foundation for developing the proposed maturity and governance frameworks.

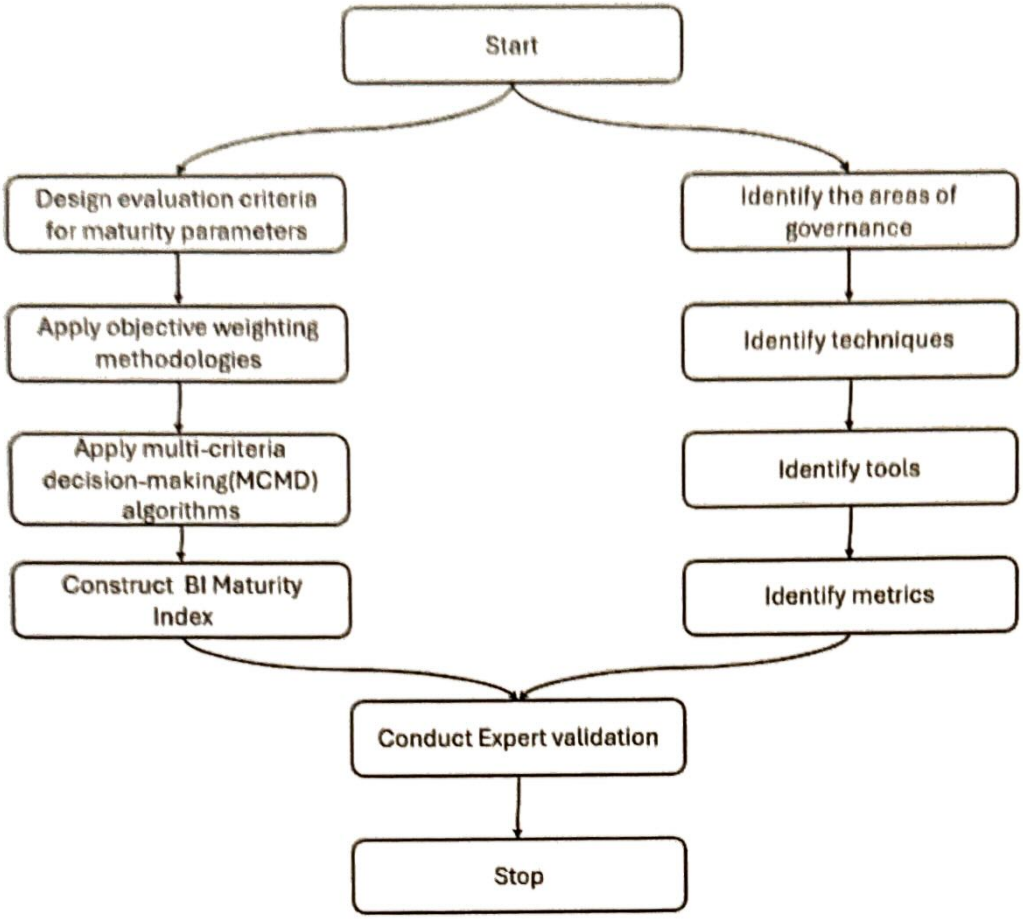
Upon completion of the literature review, the research will transition into a structured framework development phase, focusing on two distinct yet interconnected components: the maturity assessment framework and the governance framework. The maturity assessment framework will be carefully designed, incorporating quantitative criteria that cover critical capability dimensions of modern data visualization tools. These criteria will span several layers and each layer will encompass comprehensive evaluation parameters to facilitate precise assessment and benchmarking.

Following the conceptualization and structural design phases, quantitative metrics for maturity assessment will be rigorously formulated. To ensure objectivity and minimize subjective biases inherent in traditional expert-driven evaluations, advanced objective weighting methodologies will be systematically applied. Advanced multi-criteria decision-making (MCDM) algorithms will then be applied to synthesize disparate evaluation criteria into a coherent and transparent BI Maturity Index (BIMI). This unified index, presented on an intuitive numeric scale, will enable organizations to clearly understand their maturity standings and systematically pursue incremental capability enhancements.

Simultaneously, the research will involve developing an elaborate governance framework explicitly structured around different discrete areas of governance. For each governance area, specific tools, techniques, and evaluation metrics will be identified and clearly defined, providing detailed guidance for effective implementation, continuous monitoring, and sustained improvement. This governance structure will be designed to support the practical needs of organizations.

Finally, to ensure the robustness, reliability, and practical utility of the proposed maturity and governance frameworks, the Delphi method of expert validation will be rigorously applied, involving iterative rounds of consultations with BI experts and practitioners. Such an expert-driven validation will significantly enhance both the theoretical soundness and practical applicability of the final frameworks, ensuring that they meet the high standards expected by contemporary data-driven organizations.

The below flow chart provides an overview of the methodology:



Methodology Flow chart: Maturity and Governance Framework

Expected Results/Outcomes

The expected outcomes of this research are as follows:

- A defined, validated, and practically implementable Multi-Layer BI Maturity and Governance Framework suitable for contemporary data visualization stacks.
- Clearly defined and objectively measurable maturity and governance metrics, enabling organizations to benchmark, track, and improve BI practices continuously.
- A foundational research contribution to the BI governance field, guiding future industry and academic studies towards systematic maturity and governance evaluation.

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